# Engineering Economy: Getting Personal

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**Abstract** – To some, sitting through an Engineering Economy lecture can be as interesting as watching paint dry. However, throw in a few personal examples, and Engineering Economy can become a life changing course. In this paper I describe an active learning approach to Engineering Economy where numerous hands-on labs accompany a standard lecture style course. More importantly, these labs apply fundamental Engineering Economy concepts to everyday life events, events in which students will become involved with numerous times throughout their personal and professional lives.

*Keywords:* active learning, engineering economy.

## BACKGROUND

Engineering Economy involves formulating, estimating, and evaluating the economic outcomes when alternatives to accomplish a defined purpose are available. Another way to define engineering economy is as a collection of mathematical techniques that simplify economic comparison [1]. In other words, Engineering Economy helps decisions makers compare alternatives for achieving a goal from an economic standpoint.

A selected review of University course catalogues turned up the following course descriptions for Engineering Economy:

- Tennessee Tech: Concepts and techniques useful in the economic evaluation of engineering alternatives.
- UT Chattanooga: Economic decision-making for engineering systems. Choice of alternatives bu equivalent annual cost, rate of return, present worth and benefit cost methods. Tax influences, decision-making, replacement policy.
- UCF: Economic evaluation of engineering alternatives and design. Time value of money and economic impact of taxes, risk, depreciation.
- Mercer: Economics in engineering decision making, interest and present worth, depreciation, economic analysis of engineering alternatives.
- NC State: Engineering and managerial decision making. The theory of interest and its uses. Equivalent annual costs, present worth, internal rates of return, and benefit/cost ratios. Accounting depreciation and its tax effects. Economic lot size and similar cost minimization models. Sensitivity analysis. Cost dichotomies: fixed vs. variable, and incremental vs. sunk, use of accounting data. Replacement theory and economic life.
- Clemson: Basic principles and techniques of economic analysis of engineering projects. Consideration of time value of money, short-term and long-term investments, replacement analysis, depreciation methods, cost allocation and measures of cost effectiveness.

This same review revealed that about half the engineering disciplines in the Southeast have some form of Engineering Economy requirement in their curriculums, and all Industrial Engineering programs require Engineering Economy. Engineering Economy also tends to be taught by Industrial Engineering departments as a service to the other disciplines.

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With over half the Engineering student population taking some form of Engineering Economy, some discussion of how it is being taught seems prudent. In this paper I present an active learning approach that uses numerous personal examples.

## ACTIVE LEARNING AND PERSONAL EXAMPLES

Why use an active learning style and personal examples? It has been cited [2,6] that students retain 20% of what they hear, 30% of what they hear and see, but by participating in some active form of learning they retain as much as 90%. This obviously gives some direction for teaching in general, but what about Engineering courses in particular?

Felder [4,5] took on a longitudinal study of active learning in a series of Chemical Engineering courses. Of significance is that this was not a single point study, but tracked a group of students over 5 semesters in which Felder used an active and cooperative learning style approach. In addition, the class size was not small, ranging from 90 to 100 students. The study compared this active learning body of students to a group of students at the same institution which were taught using the traditional lecture style approach. The results indicate that the students in the active learning group generally earned higher course grades (in Chemical Engineering courses outside the active courses), were less likely by half to leave Chemical Engineering, and a third less likely to drop out of college altogether. Students in the experimental group gave significantly higher ratings to the quality of their course instruction, the student-friendliness of their academic environment, the level of peer support they enjoyed, and the quality of their investment in their education. The active learning students also were twice as likely to pursue graduate study in Chemical Engineering.

In another study, Demetry and Groccia [3] studied the impact of using an active and cooperative learning approach on an Introduction to Materials Science course by comparing student test scores and surveys from both traditional lecture style sections and active learning sections. The active/cooperative format incorporated pair discussions and problem solving activities sandwiched in between several 10-15 minute lecture segments. The results of the study indicate that students from the active learning sections retained more knowledge and found the course to be more interesting.

In addition to active learning, Finelli, *et al.*[6] state that one of the keys to conducting a successful course involves relating the curriculum to real life problems and to current events. In other words, include practical applications drawing on personal experience or examples with which students might interact. This idea was inspired by a roundtable discussion of over a dozen science and engineering educators at one session of the *29th Annual IEEE/ASEE Frontiers in Education Conference* in San Juan, Puerto Rico.

These examples along with many others emphasize the advantages of active learning and practical examples, thus the reason for using this approach for Engineering Economy.

## ENGINEERING ECONOMY ACTIVE LEARNING LABS

I always start the first class session of Engineering Economy with the bold statement that "Of all the courses I took as a student, Engineering Economy is the one that has by far had the greatest impact on my personal life". I go on to say that Engineering Economy has helped me assess when to take a loan or pay cash, what type of home mortgage to pursue, whether or not to refinance, what the impact is of paying off a loan early, etc… I have turned these personal experiences into in-class lab assignments. The goal of these labs is to show that the principles of Engineering Economy help with your personal as well as your professional decisions.

The class is typically taught by alternating a lecture on one day followed with a computer lab the next. The labs make extensive use of the Microsoft Excel ® spreadsheet software. My experience over the last 4 years indicates approximately 10-20% of students have no spreadsheet experience, but all have basic computer skills (i.e. can operate Windows). The labs are designed to both build their knowledge of Engineering Economy and increase their competence in using spreadsheets to analyze problems. I begin the labs by demonstrating Excel built-in functions and techniques which address the Engineering Economy topic discussed in the previous lecture. I then handout the lab assignment which presents a situation and walks the students through a series of questions; thus guiding them

through an economic analysis. Students are encouraged to help each other during the labs, and are encouraged to call me over to help them out. This is particularly helpful for students who are just learning Excel.

In an effort to bring some practicality into the labs, I have designed the labs around several personal experiences in which I have applied Engineering Economy principles in my personal life. Following, are selected examples of the in-class labs.

**Lesson 7 – Finding Present Value for a Series of Cash Flows (Ex. 5)**

The Lesson 7 in-class lab follows the discussion on finding the present value (PV), future value (FV) or annual worth (AW) of a series of cash flows. Exercise 5 of the in-class lab discusses a situation in which I had set up a college savings plan for my son when he was born. I ask a series of questions which helps determine how much I should invest each year (AW) such that I can cover his college tuition. I then ask the students to perform a simple sensitivity analysis (part d and e) if college tuition rates increase at a greater rate. If they setup their spreadsheets correctly, this analysis can be performed by changing a single value in one cell.

> Lesson 7, Exercise 5 – Help me with the following: My son is currently in Kindergarten. When he was born, we opened a college savings plan and currently have $5000 in his account. Assuming he starts college after he graduates from high school, how much must I put in his account each year, including the 4 years he is in college, such that $0 remain in his account upon graduation.
>
> a) What will be the cost of education (tuition only) when he is ready to start college? Let's make the following assumptions. The current tuition for college in a public institution is $6,000. It is increasing at a rate of 6% per year. What will the cost be in each of the 4 years he is in college?
> b) Create the cash flow diagram, starting with the $5000 currently in the account, and noting the annual installments I will make starting at the end of year 1 through his last year in college, and note the cash outflows from the account for the 4 years he is in college.
> c) Determine the annual installments that I must put into his account such that $0 will remain in his account upon graduation. Assume a 6% interest rate.
> d) What are the annual installments if college tuition increases at 9% per year?
> e) What are the annual installments if college tuition increases 9% per year, but the college savings plan returns only 5% per year?

**Lesson 9 – Refinancing Option In-Class Case Study Lab**

The Lesson 9 in-class lab follows a lecture on nominal and effective interest rates. I therefore use one of the most common places one will run into the use of nominal and effective interest rates, a home mortgage. In this lab I present them with a decision I had to make on whether to refinance my own home mortgage when interest rates fell. This lab helps the student go through the thought process behind making this decision and shows how the decision is based not only on the new payment but on how long the payee plans on keeping the loan.

> Lesson 9 - When moving to Macon, I took out a 15 year $100,000 loan with a 6.125% APR, compounded monthly. I have already made 12 payments.
>
> a) What is my current P&I payment (what is A on this 15 year $100,000 loan)?
> b) What is the present value and future value of the remaining payments of my current loan?
>
> I have a chance to refinance by taking out another 15 year $99,200 loan with a 4.75% APR, compounded monthly. (Note the principle is different because new closing costs ($3,200) have been rolled into the remaining principle of the existing loan ($96,000), so that no out of pocket expenses are incurred).
>
> c) What is the new P&I payment?
> d) What is the present value and future value of this new loan (this is an easy question)?
> e) What will be the present value and future value of each loan in two years (24 months)? Keep in mind that 12 months had already been paid on the first option.
> f) The difference between the monthly installments of each option is approximately $79. What is the future worth of these monthly savings two years from now, if I invested this savings in a Money Market paying 3%?

g) Clearly, if I were to keep the home for 15 years, re-financing would be the best option. However, would you advise me to re-finance my loan if I plan on moving in 2 years?

**Lesson 15 – Rate of Return Analysis In-Class Lab**

The Lesson 15 in-class lab emphasizes how rate of return and interest payments are based on the idea of un-recovered balance. The lab is centered on a home mortgage. Students create a table showing which portions of a monthly payment are applied to principal and to interest. Students are often surprised to learn that it takes almost 21 years to pay off half of a 30 year mortgage. They also have an opportunity to see how additional payments towards principal greatly reduces the time it takes to pay off the mortgage.

Lesson 15 - You have just taken out a loan for $100,000 at 5.875% interest for 30 years.

a) Determine your monthly payments. (Hint: use the PMT Excel Function).

Using the interest on un-recovered balance approach described in class, develop a table showing the principal and interest payments for each of the 360 periods. A reprint of the class example is shown below.

| Year | Beginning Unrecovered Balance | Interest on Unrecovered Balance | Cash Flow | Recovered Amount | Ending Unrecovered Balance |
|---|---|---|---|---|---|
| 0 | | | ($2,000) | | ($2,000.00) |
| 1 | ($2,000.00) | $200 | $527.60 | $327.60 | ($1,672.40) |
| 2 | ($1,672.40) | $167 | $527.60 | $360.36 | ($1,312.04) |
| 3 | ($1,312.04) | $131 | $527.60 | $396.40 | ($915.64) |
| 4 | ($915.64) | $92 | $527.60 | $436.04 | ($479.61) |
| 5 | ($479.61) | $48 | $527.60 | $479.64 | $0.03 |

b) How much interest will be paid over the life of the loan?
c) If you were to sell the house and terminate the loan at the end of year 5, how much principal do you still owe the mortgage company?
d) At what point in time (in years), have you paid off exactly 50% of the principal?
e) If interest rates rise to 9.5% compounded monthly, how much interest would you pay for the life of the loan?
f) Returning to the 5.875% interest situation, after 24 months of payments, your rich uncle gives you $10,000 which must be applied immediately to your home. By applying this money to your mortgage, how many months has the mortgage been reduced?

## STUDENT FEEDBACK

While I have not tried to assess retention and interest level by comparing a lecture only style course to the active learning style, I do have numerous anecdotal instances which indicate students are engaged.

Older students, or at least those who have a mortgage, tend to get real interested in Lesson 9 and Lesson 15. I am often approached during or after a class with comments such as:

"I wish I'd known about this when I was thinking about re-financing."

"I'll have to show my parents these techniques since they are considering taking out a second mortgage."

"I need to setup one of these tables for my own mortgage."

I have also been approached by students about car purchasing or leasing decisions. One student was considering purchasing a house and renting out rooms to other students. And then I have been approached with scary questions such as:

> "I've got 5 credit cards which I've maxed out. Which one do you think I should pay off first. Or, I can roll all these cards over to a new card which is interest free for the first 12 months. What do you think?"

In addition, comments from my end-of-semester course evaluations indicate that students appreciate the lecture / lab active learning approach. Selected comments include:

> "Format was good. Split time well between class time and lab time."
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> "I enjoy the format of the course. By spending time in the computer lab, I have been able to learn more about using Excel than I have ever known, and not just engineering economy uses. The lab also gave us a chance to learn how to use a computer to calculate the formulas that we learned in class."
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> "Real-world anecdotes were very interesting, helped to prove the worth of the subject matter."
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> "The labs helped me understand the material and they also taught me a lot about excel."

## SUMMARY

Research indicates that an active learning style and practical examples help improve student retention of knowledge and helps raise student interest and engagement in the classroom. In this paper I present several examples of active learning labs using personal examples in an Engineering Economy course. Feedback from students indicate they are engaged and very much enjoy the lecture / lab format.

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